Federal Communications Commission
Spectrum Policy Task Force

Report of the Unlicensed Devices and Experimental Licenses Working Group

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Unlicensed Devices and Experimental Licenses Working Group

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Disclaimer

The findings and recommendations contained in this Report are those of the Unlicensed Devices and Experimental Licenses Working Group members, and do not necessarily reflect the views of the Commission, Commission management, or the Spectrum Policy Task Force.

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I. INTRODUCTION

The primary mission of the Unlicensed Devices and Experimental Licenses Working Group ("UEWG" or "Working Group") was to examine the Commission's rules and policies regarding the operation of Part 15 unlicensed low power transmitting devices and the authorization of experimental licenses under Part 5. With regard to unlicensed devices, this review was conducted to determine the current status of unlicensed device operation, including available spectrum, interference potential, types of devices, applications, and regulatory models, with a view towards identifying changes or alternative approaches for regulating unlicensed devices that might promote more efficient and productive use of the spectrum. The Experimental Radio Service (ERS) was also examined to determine the extent to which improvements can be made that would further encourage innovation and technical development.

The work of the UEWG included examining the comments filed in response to the *Public Notice* issued by the Spectrum Policy Task Force on June 6, 2002, and the comments and statements made by the participants at the Public Forum held on August 1, 2002.[1]

II. UNLICENSED DEVICES

This section provides a definition of unlicensed devices used for the purposes of this report and presents a discussion of the uses and benefits of unlicensed devices; a brief history of the development of the Commission's regulatory framework for unlicensed devices; a brief discussion of some of the issues/findings with regard to unlicensed operation; and, the recommendations of the UEWG.

A. Background

1. Definition of Unlicensed Devices

The rules for unlicensed use of radio frequency (RF) devices are contained in Part 15 of the Commission's rules.[2] Three types of unlicensed devices are defined and regulated under the Part 15 rules:

Intentional radiators - these are devices that intentionally generate and emit RF energy by radiation or induction. Typical intentional radiators include cordless telephones, remote control toys, and other low power transmitters.

Unintentional radiators – these are devices that generate and use RF energy within the device but are not intended to emit RF energy by radiation or conduction. Typical unintentional radiators include devices such as personal computers, printers, disk drives, and other digital devices that have internal "clocks" or circuitry used for timing within

[1] The comments and transcripts of the Public Forum are on file in Docket 02-135

[2] 47 CFR Part 15.

the device, TV interface devices such as VCRs, and carrier current system. Radio receivers, such as television receivers and AM/FM radios, are unintentional radiators.

Incidental radiators – these are devices that generate RF energy during the course of their operation but are not intentionally designed to generate or emit that energy. Typical incidental radiators include motors and mechanical light switches.

For the purposes of this report, the terms "unlicensed devices" and "unlicensed consumer devices" are used to refer to intentional radiators or low power transmitters regulated under Part 15. That is, as identified in this section of the report, unlicensed devices would include cordless telephones, remote control toys, etc. Special emphasis is given to unlicensed devices used for computer and data networking applications.

2. Non-interference Requirement

The basic premise of all Part 15 unlicensed operation is that unlicensed devices cannot cause interference to licensed operations nor are they protected from any interference received. The operational parameters for unlicensed operation are set forth in Section 15.5 of the rules, as follows:

> (a) Persons operating intentional or unintentional radiators shall not be deemed to have any vested or recognizable right to continued use of any given frequency by virtue of prior registration or certification of equipment,
>
> (b) Operation of an intentional, unintentional, or incidental radiator is subject to the conditions that no harmful interference is caused and that interference must be accepted that may be caused by the operation of an authorized radio station, by another intentional or unintentional radiator, by industrial, scientific and medical (ISM) equipment, or by an incidental radiator.
>
> (c) The operator of a radio frequency device shall be required to cease operating the device upon notification by a Commission representative that the device is causing harmful interference. Operation shall not resume until the condition causing the harmful interference has been ccrrected.

3. Uses of Unlicensed Devices

The availability of spectrum for unlicensed operations has spawned a significant market for unlicensed devices. These devices range from simple consumer devices, such as, cordless telephones; remote control toys; garage door openers; and, baby monitors; to sophisticated business and commercial applications, such as security systems; inventory control systems; manufacturing controls; and, business computing networks.

Product	Penetration	Number per Household	Total Installed Base (millions)
Cordless Phones	81.0%	1.50	
FRS)			
Baby Monitors	**10.5%**	1.38	15.52
Home Security Systems	18.0%	1.10	21.21
Cars			

Source: CEA Comments, Docket 02-135, September 30, 2002

The growing popularity of computer networking has stimulated a heightened interest in unlicensed technology and one of the fastest growing applications of unlicensed devices is for wireless local area networks (WLANS). Because most businesses and many homes now have multiple computers, users often find it desirable to install local area networks to share resources such as printers, scanners and broadband or dial-up Internet connections. Developing a local area network using wireless unlicensed devices can be cost-attractive when compared with the costs of wired networks and offers the added benefit of instant portability.

The same spread spectrum technology that has been used for cordless telephones and other unlicensed devices has been adapted to meet the surging demand for computer and data networking. Among the more popular of these unlicensed devices are wireless daa devices that operate in the 2.4 GHz band in accordance with the 802.11b or "Wi-Fi" standards and protocols developed by the LAN/MAN Standards Committee (LMSC) of the Institute of Electrical and Electronic Engineers.[4] Unlicensed devices operating under the 802.11b/Wi-Fi protocols can he used to link computers or other digital devices at distances up to about 150 feet and with data rates of up to 11 Mbps. Other IEEE protocols have recently been developed, such as 802.11a which operates at 5 GHz and 802.11g which is an extension of 802.11b, that provide even higher data rates. Another unlicensed wireless networking standard is HomeRF developed by the

[3] Comments of CEA in Docket No. 02-135, dated September 30,2002

[4] The IEEE is a "on-profittechnical professional organization. Among other activities, the organization develops technical standards. The IEEE 802.11 Working Group is charged with developing standards for wireless local area networking devices. Examples of Wi-Fi products can be seen at http://www.weca.net/OpenSection/certified_products.asp?TID=2

HomeRF Working Group.' This technology provides data capabilities similar to Wi-Fi hut also includes voice capability.

Unlicensed consumer devices are also being developed to provide very short-range (on the order of 10 meters) wireless "personal area" networks (WPANs). "Bluetooth," which uses **2.4** GHz spread spectrum frequency hopping technology, **is** the dominant WPAN technology at this time.[6] Bluetooth devices are beginning to he included in many devices such as mobile radiotelephones, laptop computers, printers and personal digital assistants (PDAs) and some experts believe that it could become a standard feature in many consumer electronic devices. Finally, other unlicensed technologies such as power line carrier (PLC) systems that use the electric power lines to transmit data and ultra wideband (UWB) devices are being developed and hold great promise for providing consumers with new data and computer networking capabilities.

The Synergy Research Group recently reported that the wireless LAN market posted its eighth consecutive quarter of doubledigit growth and that total growth from 2000 has been over 150 percent.' It estimates that over 5 million unlicensed wireless LAN devices were shipped in 2001 and predicts that 21 million Americans will be using wireless LAN devices by 2007. Gartner Research predicts that by 2006 approximately $5.6 billion per year will he spent on Bluetooth technology and more than 560 million Bluetoothenahled devices will be purchased by businesses and consumers.' It is estimated that by 2004 over 45 million business laptop computers will use the Wi-Fi standard.' Analysts project that by 2007 there will be over 90 million Wi-Fi enabled devices worldwide and over 40 million people roaming in Wi-Fi hotspots.[10]

4. Regulatory History of Unlicensed Operation

The rules for unlicensed use of RF devices were first established approximately sixty years ago." In 1938, the Commission allowed devices employing relatively low level RF signals to he operated without the need for individual licensing as long as their operation caused no harmful interference to licensed services and the devices did not generate emissions or field

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'The HomeRF Working Group **was** formed in 1998 and includes more than 70 companies from the personal computer, consumer electronics and related fields. *See* http://www.homerf.org/products/ for **an example** of HomeRF devices.

[6] Bluetooth was created by Ericsson in 1994. The Bluetooth Special Interest Group (SIG) **was** formed in 1998 to develop and **promote an** open standard for short-range wireless networking. Charter members of the SIC include Ericsson, Intel, IBM, Nokia and Toshiba. Information on Bluetooth products can be seen at http://www.bluetooth.com/tech/products.asp .

'Comments of Consumer Electronics Association, Docket **No.** 02-135, p. 3

[8] *Communications Doily,* September 5, 2002.

[9] Roger O. Crockett, *et al.*, "All **Net, All** the Time," *Business* ***Week,*** April 29, 2002

[10] Elizabeth V. Mooney, "Joltage Aspires to be Wi-Fi Heavyweight," *RCR* ***Wireless News,*** April 22, 2002, **at** 20.

[11] This historical discussion is based on the *Report and* ***Order*** in Docket 87-389, 4 FCC Rcd 3493 (1989).

strength levels greater than a specified level that was chosen to ensure that the device generally would not cause interference.[12] Typical kinds of equipment operated under these regulations were wireless record players, carrier current communication systems (such as, campus radio systems) and remote control devices.

At the time the original unlicensed standards were adopted, most Part 15 RF devices were designed to operate below 30 MHz and compliance with the field strength limit was relatively easy to achieve. However, as the industry designed products intended for operation on higher frequencies, it became more difficult to meet the field strength limit because the allowable field strength level decreased as the operating frequency increased. Over the years the Commission amended and expanded Part 15 of the rules to permit the norrlicensed operation of devices at higher field strengths in certain higher frequency hands in those cases where it could be determined that the wide-spread use of such products would not result in harmful interference to authorized radio services.

In the 1950s, the Commission adopted new technical standards for devices such **as** radio receivers and low power transmitters operating in the **27** MHz bard and above 70 MHz. In the 1960s through the 1980s, additional provisions were made under Part 15 to permit the operation of equipment such as wireless microphones, telemetry systems, garage door openers, TV interface devices (*e.g.*, video cassette recorders), field disturbance sensors (*e.g.*, anti-pilferage systems for retail stores), auditory assistance devices, control and security alarm devices, and cordless telephones.

In 1985, Commission first authorized the operation of norrlicensed spread spectrum systems in the 902-928 MHz, 2400-2483.5 MHz, and *5725-5850* MHz bands under Part 15 of the rules at a power level of 1 W which was significantly higher than previously permitted unlicensed use in other bands.[13] Spread spectrum techniques, developed by the US military for use during World War II, have high immunity to interference and low probability of intercept. These same qualities make spread spectrum systems an attractive technology for consumer use. The authorization of spread spectrum devices was significant for two reasons. First, the Industrial, Scientific and Medical (ISM) hands at 902-928 MHz, 2400-2483.5 MHz and 5725-5850 MHz are generally used for non-communications purposes ***so*** concerns about interference

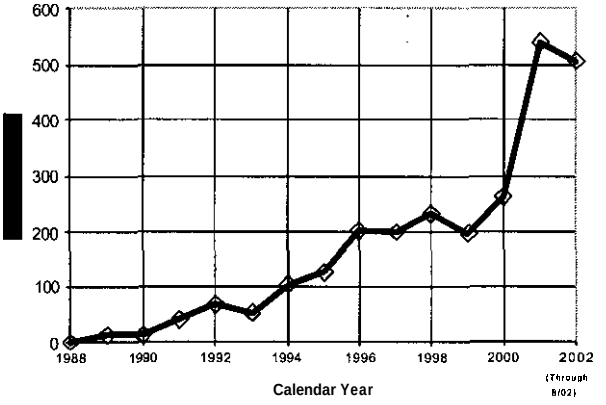
[12] The limit applied to these early deviceswas 15 microvoltslmeter (uV/m) at a distance equivalent to the wavelength of the operating frequency divided by 2p.

[13] Spread spectrum communication systems use special modulation techniques that spread the energy of the signal being transmitted over a very wide bandwidth. The information to be conveyed is modulated onto a carrier by some conventional techniques, usually a digital modulation technique, and the bandwidth of the signal **is** deliberately widened by means of a spreading function. The spreading technique used in the transmitter **is** duplicated in the receiver to enable detection and decoding of the signal. Spread spectrum systems offer two important technological advantages over conventional transmission schemes. First, the spreading reduces the power density of the signal at any given frequency within the transmitted bandwidth, thereby reducing the probability of causing interference to other signals occupying the same spectrum. Second, the signal processing in spread spectrum systems tends to suppress undesired signals, thereby enabling such systems to tolerate strong interfering signals.

to primary services were small.[14] Therefore, interference to other licensed and allocated services was less of a concern and higher power could he allowed. Second, the ISM frequencies or "unlicensed hands" provided sufficient bandwidth to permit the development of unlicensed devices with high data rate capabilities.

The Commission's spread spectrum rules have been highly successful and have led to the development of a wide range of useful consumer products and devices. The number of unlicensed devices authorized has grown steadily over the years. Fueled by the growth of computer networking applications, such as Wi-Fi, and Bluetooth, the number of spread spectrum authorizations skyrocketed to 262 in 2000 and then 506 in the first eight months of 2002. The following graph shows the annual growth in spread spectrum authorizations.

Part 15 Spread Spectrum Equipment Authorizations



In its 1989 revision of the Part 15 rules, the Commission established new general emission limits in order to create more flexible opportunities for the development of new unlicensed transmitting devices. These moregeneral rules allow the operation of unlicensed devices for any application provided that the device complies with specified emission limits. This revision **also** established new "restricted hands" to protect certain sensitive radio operations, such **as** satellite downlink bands, and federal government operations, and prohibited transmissions by unlicensed devices in those bands.

The Commission has continued to update and expand the Part 15 rules to provide new opportunities for unlicensed operation, including the designation of additional frequency hands for unlicensed use. For example, in 1993, the Commission designated 20 megahertz for unlicensed personal communications services (Unlicensed PCS). Ten megahertz was set aside for asynchronous (primarily data) and ten megahertz was set aside for isochronous (primarily voice) operations

[14] For example, these bands are used **for** industrial purposes, including heating and sealing materials, such **as** plastics, during manufacturing processes. **The** 2400 MHz band **is the** location **of** most, if not all, current and recent model consumer microwave **ovens.**

In 1995, the Commission made the 59-64 GHz band (millimetenvave band) available for use by unlicensed devices.[15] The Commission noted that the spectrum would be suitable for short-range, high data rate, broadband applications, such as wireless computer-to-computer communications, and determined that licensing was not needed because of the limited potential for interference, due to shorter propagation distances of these frequencies. Interference potential would also be limited by the narrow beam width of point-to-point antennas, which are likely to be operating in this range.

The Part 15 rules were amended in 1998 to provide for operation of Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band (5.15-5.35 GHz and 5.725-5.825 GHz).[16] Again, the Commission recognized that developments in a number of different digital technologies have greatly increased the need to transfer large amounts of data from one network or system to another. In making this spectrum available, the Commission concluded that providing additional spectrum for unlicensed wideband operation would benefit a vast number of users, including medical, educational, and business/industrial users.

The bands available for unlicensed spread spectrum, Unlicensed PCS, millimeterwave and UNII devices are summarized below:

Bands	Year Authorized	Freauencies (MHz)
ISM/ Spread Spectrum	1985	902-928,2400-2483.5 & 5725-5850
Unlicensed PCS	1993	1910-1930 & 2390-2400
Millimeterwave	1995	59,000-64,000
U-NII	1998	5150-5350 & 5725-5825
Millimeterwave (Expansion)	2001	57,000-59,000

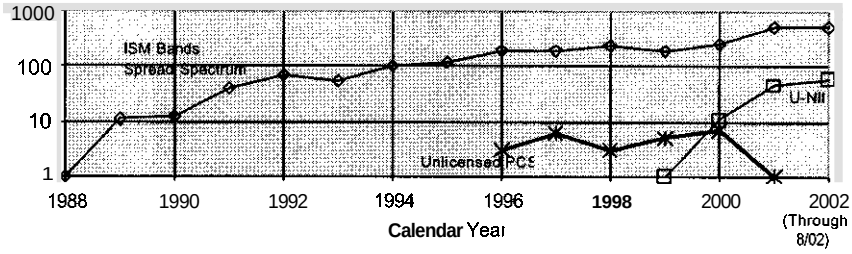
The following chart also indicates that not all unlicensed operations have been successful.[17] When the Unlicensed PCS band was created in 1995, it was expected that devices operating in this spectrum would consist of new cordless telephones, local area networks in offices, and other kinds of short-range communications. The lack of Unlicensed PCS devices on the market today may be due to the fact that the band had to be cleared of existing fixed microwave users for ubiquitous use to occur and the bandwidths available were relatively modest when compared to other unlicensed bauds. In fact, many of the data applications foresem for the

[17] This band was later expanded to cover 57-64 GHz. See 47 C.F.R. § 15.255.

[16] The 5 GHz band is also used on an unlicensed basis in Europe. However, the available spectrum, referred to as the HiperLAN2 bands, is slightly different than the US U-NII hands. While the two share the 5.15-5.25 GHz portion, the HiperLAN2 upper band stretches from 5.470-5.725 GHz.

[17] The 57-64 GHz hand is not shown in the chart. It is a relatively recently authorized hand and is in an area of the spectrum with great technological challenges. Two models were authorized in this hand in 2000 and three models have been authorized so far in 2002.

Unlicensed Equipment Authorizations



Unlicensed PCS bands are now being served by devices operating in the spread spectrum and U-NII hands.

B. Issues/Findings

In some respects, the success of unlicensed operation has been a mixed blessing. On one hand, unlicensed devices have improved productivity, provided consumers with new products and services and generally benefited the US. public, its industries, and its economy. On the other hand, there are concerns that the frequency hands being used by unlicensed bands will soon become subject to the "tragedy of the commons," that is, interference and overcrowding; and that this potential problem coupled with the lack of new spectrum for unlicensed devices, will stifle innovation and development. The need for "more unlicensed spectrum" was the most common theme among comments, workshops, and other discussions with interested parties.

1. Need for Additional Unlicensed Bands

Although there were a few parties who questioned this need, the significant majority of parties commenting on this issue stated that additional spectrum should be made available for unlicensed use. Microsoft, for example, urged the Commission to allocate additional spectrum below 2 GHz and at **5** GHz for unlicensed broadband uses. It argued that such spectrum could be used to supplement cable and DSL services and could 'tjumpstart" the creation of competitive wireless broadband networks in the U.S. Similar support for additional unlicensed spectrum was expressed by Cingular, Cisco Systems, Inc., the Consumer Federation of America, Ericsson, Information Technology Industry Council, Motorola , Proxim, Rural Telecommunications Group, Wireless Ethernet Compatibility Alliance and others. In their joint reply comments, the New America Foundation, Consumers Union, *et* ***al,*** state that there is tremendous support in the record for the allocation of additional frequency bands of spectrum for unlicensed use, particularly to facilitate broadband wireless networking.

Based on the record, it is generally perceived that the creation of unlicensed bands has been very successful in allowing the rapid introduction of new technology and that additional unlicensed hands would create more such opportunities. However, there was a general lack of information on how the Commission should create such unlicensed bands and what priority they should be given relative to other spectrum requests.

The UEWG finds while it is not practical at this point to develop estimates of the optimal amount of spectrum that should be provided for unlicensed operations, it appears that additional spectrum is needed for unlicensed devices. This is particularly true in light of recent trends towards increased use of short distance wireless systems, which use fixed infrastructure to provide end-to-end connectivity. In the large area wireless systems that existed prior to the formal regulation/licensing of radio systems it was difficult to control mutual interference without entry and technical regulation. As radio ranges become smaller, this justification for licensing becomes less universal. An ever increasing fraction of today's radio applications have ranges measured in yards rather than miles.

The UEWG finds that while there is great interest in making available additional unlicensed spectrum, there is no consensus on how such spectrum should be obtained, especially at frequencies in the lower regions of the spectrum, *i.e.*, at **5** GHz and below. The ISM/spread spectrum bands were rather easy to designate for unlicensed use because the microwave ovens and other ISM equipment using them made these bands of little value to most traditional spectrum users. However, having used this opportunity there is little "low hanging fruit" left for unlicensed band use. The contentiousness of the ultra wideband rulemaking shows that even very low power unlicensed use of normally licensed hands can become very controversial. Thus, any expansion of unlicensed use will have to pay careful attention to legitimate concerns of other spectrum users and consider untraditional approaches to obtaiung spectrum use.

2. Protocols/Etiquettes

After the need for more spectrum, the next most recurring issue was that of spectrum protocols or etiquettes. Spectrum protocols or etiquettes are the rules **or** procedures that must be used by unlicensed devices to gan access to the spectrum. For example, a simple spectrum etiquette might require that a device "listen" for a certain period of time to ensure that the spectrum is unoccupied before it begins transmitting and that transmissions be limited to a fixed amount of time so that no one device can occupy the spectrum all of the time. There are currently mandatory protocols in Part 15 of the rules for Unlicensed PCS systems.[18] In addition, industry groups such as IEEE have developed and are developing voluntary pmtocols for certain types of unlicensed devices. For example, IEEE Task Group 802.15.2 is developing recommended practices for the collaborative use of Wi-Fi and Bluetooth devices in the **2.4** GHz to ensure that these devices can co-exist and do not interfere with each other."

There are theoretical reasons to believe that the overall efficiency and productive use of a radio hand by geographically distributed users with random time demands (such as might be the case for data communications) can be improved through the use of a well designed common spectrum protocol. There are also economic arguments that question whether marketplace forces alone would result in competing protocols reaching a stable equilibrium in the marketplace that would maximize the throughput of a band.

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[18] *See* §§ 15.321, **15.323.** Some parties have stated that the specific nature of this protocol is one reason why this service has met with little commercial success.

[19] The IEEE **Task** Group is looking at adaptive power control, adaptive frequency hopping and other collaborative approaches to reduce interference.

The UEWG therefore finds that the advantage of using a homogeneous set of protocols in a band to improve overall efficiency seems very promising and that a government role with regard to setting those protocols may be appropriate in certain situations. However, real implementation issues remain in how to recognize when such government action should be taken and when such action may not he beneficial. While technology may move ahead at "Internet time," FCC regulations of necessity are adopted on "APA time," which is considerably slower. Thus, there is real concern about the possible timeliness of an FCC-adopted technically detailed protocol and ensuring that protocols are updated as technology advances. In this regard, the UEWG supports voluntary industry efforts to the extent possible. Where government intervention is deemed appropriate, the UEWG suggests that the procedures for the current Internet protocols could serve as a model. The current Internet protocols have been very successful. They were first developed and specified for the ARPANET by its government agency sponsor. However, this selection was done by the agency funding the project and was not subject to sometimes lengthy APA procedures. Given that the initial protocols were in place, the Internet protocols have evolved by a consensus process without the APA or any formal regulatory process. In this evolution, Internet protocols have generally kept place with technology. This is different than the way FCC selected and continues to maintain protocols in unlicensed PCS. The UEWG believes that there may he advantages in creating a regulatory framework where wireless protocols can evolve with changing technology without the delays associated with APA rulemakings.

3. Noise Floor/Aggregation

While the general emissions standards of Section 15.209 have been in the Commission's rules since 1989, the ultra wideband rulemaking refocused attention on the issue of whether unlicensed devices are raising the apparent noise floor to other users of the spectrum and either limiting their range or raising the cost of infrastructure to serve a given communication market. There appears to he no available data in the United States that show what the trends have been with regard to ambient radio noise or data that show how much of the noise present is due to unlicensed intentional emitters or any other specific types of source." This is no generally accepted methodology for measuring ambient noise levels and format for recording such information.

The UEWG believes that the absence of such data may serve to prolong the controversy on this topic and that therefore there would be tangible benefits for the FCC to cooperate with spectrum users to develop a long-term spectrum monitoring program to observe trends in ambient noise levels. Moreover, such data are necessary for implementing Spectrum Policy Task Force recommendations, most specifically the interference temperature recommendation. The UEWG believes that a well-designed multiyear program would have significant benefits and improve spectrum management in general.

[20] The FCC's Technological Advisory Committee has observed, " Until [noise floor] information is organized and analyzed, the FCC will not have a firm basis for deciding whether current noise standards are too tight, too loose. or maybe even just right." *Sixth Meeting Report of the TAC* at 9.

4. Millimeterwave Bands

The upper limit of commercially usable spectrum is increasing rapidly with advances in electronics. PCS radiotelephones operating at 2 GHz and DBS systems operating at 12 GHz are now common consumer items with products available in the $100200 price range. Prior to 1995, the highest frequency authorized for nowexperimental use was 40 GHz, now it is 77 GHz and there is a current proposal to extend that to 95 GHz.[21]

The frequencies above 30 GHz are commonly called "millimeterwave" frequencies because of their wavelength. At these frequencies, radio propagation decreases more rapidly with distance than at other frequencies and antennas that can narrowly focus transmitted energy are practical and of modest size.

While it is difficult to say what regulatory approach should he used for millimeter wave spectrum, the physics of this band are *so* different than lower bands as to bring into question most ofthe fundamental precepts of radio regulation. This results both from the high propagation losses due to gas absorption of radio signals and the ease of building antennas with very narrow beams. While licensing is the general presumption at lower frequencies, the physics of these frequencies appear to justify a ***de novo*** approach to considering regulatory schemes on a case-by-case basis. It may well be reasonable to question whether unlicensed use should he a major type of use in these higher hands, rather than one restricted to a small set of bands.

5. A Special Case: Wireless ISPs and Point-to-Point Systems

The past decade has seen the creation of unlicensed devicehased telecommunications services. The most recent of these being the wireless Internet service provider or WISP – that uses unlicensed equipment to provide Internet service to third parties. These providers use equipment that was basically designed and authorized as unlicensed Part 15 wireless LAN equipment. For example, most connectivity with WISPs is throughuse of Wi-Fi or IEEE 802.11b devices. In addition, unlicensed devices are also being used to provide point-to-point microwave service. Unlicensed systems, for example, are being used by cellular and PCS providers for emergency and other backhaul operatons to connect cell sites or base stations to the network.

Under Part 15, equipment and devices are approved as a "complete" system, *i.e.*, a transmitter and associated antenna.[22] This ensures that the device is not used improperly and does not cause interference to other services or uses. This approach makes sense for most Part 15 consumer devices. However, in providing service to an area, WISPs often want to select an antenna that is optimized for local circumstances. Under present Commission rules, they are limited to antennas sold with the system. This may limit the available technical choices and result in higher costs due to lack of effective competition for antennas. In addition, both WISPs and point-to-point microwave system operators have suggested that higher power should be permitted for unlicensed operation in rural areas. The WISP community has indicated, for

[21] *See Notice of Proposed Rulemaking* in Docket No. 02-289.

"Devices may be approved for use with several antenna and output power combinations.

example, that it could bring broadband service to more areas if it was allowed higher power in rural areas.

A number of commenting parties also supported the adoption of additional technical flexibility for unlicensed use in rural areas. For example, the Part-I5 Organization recommends that more power be permitted in rural areas to overcome distance and lineof-sight problems. Dr. Krantz of the University of Wisconsin states that in rural environments interference in the unlicensed bands is not an issue but communications range is, and suggests doubling or tripling the effective power in these cases.

The UEWG finds that the general concept of approving complete systems is appropriate for consumer-type unlicensed devices. However, this approach may be overly burdensome and unnecessary for unlicensed devicehased service providers, such as, WISPs and point-to-point microwave system operators. The UEWG finds that providing additional flexibility for these specific situations appears justified and should be investigated further. Further, the UEWG believes that promoting broadband to rural America is an important Commission objective and that this objective may be furthered through permitting the use of higher-powered unlicensed operations in rural areas. Allowing higher power limits in rural areas for WISPs may be a promising approach to speeding the rural growth of broadband.

C. Unlicensed Device Recommendations

Based on the above discussion, the UEWG makes the following recommendations with regard to unlicensed devices:

1. Additional Unlicensed Bands

- The UEWG recommends that the following three approaches be explored in order to create more spectrum opportunities for unlicensed devices:
  - Permitting unlicensed devices to make opportunistic or dynamic use of spectrum occupied by existing services;
  - Use of the noise temperature concept to permit unlicensed devices to underlay the signals of existing services; and,
  - Creating new "unlicensed bands" by band clearing.

These approaches are described in more detail below

Opportunistic or dynamic use of existing bands by unlicensed devices could take place either through protocols to make sure that interference is very unlikely, or under sharing conditions approved by a hand manager. The protocols approach would require a new type of etiquette that protects users from interference from unlicensed systems. For example, an unlicensed device might be required to include a GPS receiver and related software to verify whether it is in a location where it is allowed to operate so that its transmissions would not interfere with licensed users identified in a database. Such an "opportunistic" approach might be employed in the television bands to identify "white areas" where individual television channels

are not in use. Alternatively, a "listen-before-talk" or "dynamic" protocol could be used to determine whether a channel was in operation at a particular time.[23]

The other approach is to have sharing conditions managed by a band manager selected by either the FCC or the licensed user in the band. The licensed user may choose to designate a band manager in order to derive revenue from unused capacity in his existingsystem. Alternatively, an FCC-selected band might develop techniques for unlicensed sharing with licensed use and would be responsible for preventing interference.

A second way to allow increased access for unlicensed systems would be to use underlays beneath the signals of existing users consistent with avoiding harmful interference. Using the concept of interference temperature, as described earlier in this report, we might be able to allow power limits higher than the existing general Part 15 limits in cases where the unlicensed device senses the interference temperature and determines that it is below the pre-established maximum . Accurate noise temperature sensing can be complicated, but simple "worst-case" measurements can be made to ensure that my errors made are on the safe side.

The third way to create more unlicensed access is to establish new "unlicensed bands" by clearing spectrum of existing users. This would involve moving existing licensees to new bands, probably with some relocation expenses being paid **as** has been done in previous examples. These relocation expenses would have to be raised by some mechanism. We recommend that a new type of band/protocol manager be considered to manage the band with control over the protocols to be used in the band. Funds for existing user relocation could be generated by an auction for the band/protocol manager or the band/protocol manager could be required to fund relocation directly out of his user revenues.

The UEWG recommends that the Commission explore these three options and develop specific proposals for creating additional unlicensed use. The UEWG suggests that these approaches be tried in sample bands in selected spectral regions to confirm the ability of unlicensed systems to access more spectrum without impacting negatively on licensed users.

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[23] While traditional "listen-before-talk" systems suffer from the problem in which **a** receiver fails to detect the presence of a transmission because of **a poor** propagation path, a very sensitive feature detector receiver could eliminate much if not all of this problem. For example, if the signal strength in **a** room varn 5 by **30** dB due to multipath and wall attenuation, **a** feature detector inside that room with a sensitivity 40 dB below demodulation sensitivity could reliably detect the presence of a receivable signal anywhere in the room on a given frequency. **A** conventional listen-before-talk receiver would give a false indication of no signal in the locations where the signal level was very low due to location variability.

Feature detector technology was developed by military electronics researchers to detect the presence of coven communications systems. This technology increases the signal detection sensitivity of **a** receiver, which in this case means the sensitivity at which the receiver can detect the presence of a signal- not the sensitivity at which the receiver can demodulate the signal successfully. The detector works by developing **a** waveform in the receiver that is related to a key signal parameter, such as the baud rate of the transmission, and then integrating that waveform to improve the signal-to-noise ratio of the waveform. In the case of DTV, for example, the symbol rate is precisely defined as 10.76 Mbps and this could readily serve **as a** feature to detect. Feature detectors trade off detection time versus sensitivity. For example, integrating over **a** million baud, could improve the detection threshold by **60** dB over what **a** receiver could do if it had to demodulate every baud. **See** Gardner, **W.A.,** "Signal interception: a unifying theoretical framework **for** feature detection," *IEEE Trans. Comm.,* **1988,** Vol. **36, pp.** 897-906.

2. Protocols/Etiquettes

- The UEWG recommends that a new type of 'bandprotocol manager" be considered for unlicensed operation.

As suggested above, one method for making additional spectrum available for unlicensed devices is through the use of a band manager. The UEWG recommends in this regard that a new type of 'bandprotocol manager" be considered. This band/protocol manager would be selected by auction and would be responsible for ensuring that unlicensed devices did not cause interference to licensed services in the hand. The band manager would be given the authority to prescribe the protocols to he used by the unlicensed devices in the band and the ability to approve the manufacture and sale of all such devices for a specific period of time. Since the band manager would derive revenue from the sale of authorized transmitters, he or she would have marketplace incentives to develop user-friendly, high throughput protocols that would be in demand. Moreover, the band manager would have the flexibility to modify the protocols rapidly as technological changes demand. In addition, if such an approach is adopted, the UEWG recommends that the Commission consider whether this type of band manager should "sunset" after some number of years or when some other predetermined criteria, such as total units sold, is met. Sunsetting may be appropriate when sufficient unlicensed devices have been sold to create marketplace forces for backward compatibility or *de facto* standards such that change is unlikely and the band manager is no longer needed.

3. Noise Floor/Aggregation

- The UEWG recommends that the Commission develop and adopt a standard method for measuring the noise floor and develop a process, possibly involving public/private partnerships, for recurring monitoring of noise floors in various locations to determine the existence of any trends.

The lack of reliable information on noise floor in typical radio user environments and trends in such noise floors has been acomplicating issue in recent policy deliberations and will become more of an issue as we seek to use spectrum more intensively. **A** standardized methodology for measuring ambient noise and a long term process for monitoring trends will reduce uncertainty in this area, allow for increase spectrum usage, and ensure that existing users keep the interference protection that they are entitled to.

4. Millimeterwave Bands

- Recognizing the unique characteristics of the millimeterwave bands, the UEWG recommends that all future rule making proceedings for terrestrial use of frequencies above 40 GHz include a de ***novo*** review of the costs and benefits of licensing for these frequencies.

As we move into the upper frontier of radio spectrum we should **look** back and review what aspects of legacy regulation are related to the propagation characteristics that existed for bands in use when the framework was developed. To the degree that new bands have very different propagation issues, we should consider all possible approaches to regulation in selecting the approach to use in a particular context and not be limited by legacy concepts.

5. A Special Case: Wireless ISPs and Point-to-Point Systems

- The UEWG recommends that the Commission consider providing additional flexibility for WISPs and point-to-point systems to optimize the coverage of their systems and consider permitting higher power for rural operations.

The present provisions of Section 15.203 require all intentional emitter unlicensed systems under Part 15 to be approved as a system with antennas specified by the grantee (usually the manufacturer or importer). While this continues to be a reasonable requirement for most Part 15 systems, it significantly limits the ability of WISPs and point-to-point systems to build out systems to serve areas with broadband service as they often have to tailor their antenna selection to the specific service area and antenna location sites. In 1996, the Commission faced a similar issue with personal computers in which a system approach was creating unreasonable burdens in market that had moved towards "mix and match" subsystems and it adopted Section 15.102, giving personal computer manufacturers more flexibility than other unintentional emitter makers. It appears timely now to propose an analogous rule change for the specific case of WISPs and to allow them to select antennas and cables provided they verify that the overall system meets applicable equivalent isotropically radiated power (e.i.r.p.) limits.

III. EXPERIMENTAL LICENSES

A. Background

Section 303(g) of the Communications Act of 1934, as amended, (the Act) authorizes the Commission to provide for experimental use of frequencies and charges the Commission with encouraging the larger and more effective use of radio in the public interest.[24] The rules for the Experimental Radio Service (ERS) are contained in Part 5 of the Commission's rules.? The primary purpose of the ERS is to provide for experimental uses of radio frequencies and for development of techniques and systems that are not otherwise permitted under existing service rules. The ERS provides opportunity for manufacturers, inventors, entrepreneurs, and students to experiment with new radio technologies, new equipment designs, characteristics of radio wave propagation, or new service concepts related to the use of the radio spectrum. Some of the uses permitted under Part 5 are: 1) experimentation for purely scientific purposes; 2) development of equipment under Federal Government contract, foreign contract, or for export; 3) technical demonstration of equipment or techniques; 4) testing of equipment in connection with production or type acceptance, approval or certification; 5) field strength surveys or demonstration of equipment to prospective purchasers; 6) development of radio techniques, equipment, and operational or engineering data related to an existing or proposed radio service; and 7) provision of communications essential to research projects where other means of communications are not available.[26] While some experimentation and development is also allowed within existing

[24] *See* Section 303(g) of the Communications Act of 1934, as amended, 41 U.S.C. § 303(g). This discussion is based in part on the NPRM in Docket 96-256, 11 FCC Rcd 20130 (1996).

[25] *See* 47 CFR Pan 5.

[26] *See* §5.3, Scope of service.

services, such activities are restricted to applicants that are eligible to apply for a license in a particular service and on frequencies that are allocated to that service.[27]

In order to encourage innovation, the ERS tules provide great flexibility with regard to allowable frequency range, power, and emission. However, in order to protect allocated services, ERS licenses are issued on the condition that experimental operations do not cause interference to authorized stations of such services, and experimental operations are not protected from interference from allocated services. Additionally, ERS stations can be required immediately to cease operations at the Commission's request, and ERS licenses are subject to revocation without notice.

The FCC receives about 600 to 1000 ERS applications per year. Applications for experiments that use frequencies with only non-Federal Government primary users are solely within the FCC's jurisdiction. However, about 40% of he applications received deal with frequencies either shared with Federal Government users or that are assigned only to such users. In these cases information from the applications must be sent to the Department of Commerce's National Telecommunications and Information Administration (NTIA) for coordination, since NTIA is responsible for frequency management of government users. Experimental applications that are solely within the FCC's jurisdiction are usually approved in less than a month.

B. Issues and Findings

Only a few of the commenting parties to the Public Notice addressed the topic of experimental licenses. The principal concern of these parties appeared to be the delays involved in obtaining an experimental authorization due to NTIA coordination and difficulties associated with testing systems being developed for overseas markets with different allocation plans. This theme was repeated to some degree in the comments received at the Public Workshop.

1. Interference Definition

Experimental licenses are secondary operations and are conditioned on not causing interference to licensed users.[28] The UEWG believes that uncertainty over the definition of interference and its application to specific cases may result in doubts about whether a given experiment is practical on an interferencefree basis and may act as an impediment to experimentation. Similarly, incumbent users of spectrum may have uncertainty about the risk of interference to their operations from experiments and might raise objections to experiments that pose little or no risk.[29] The UEWG finds that reducing uncertainties as to what constitutes interference will remove a disincentive for experimentation as well as increase the certainty of

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[27] See, for example, developmental rules for broadcast stations under Subpart A of Part 74

[28] As secondary services, experimental licenses must also accept interference from licensed users.

[29] In an unrelated rulemaking, one party has requested that the Commission "clarify that if any experiment causes *any* interference, the experimental licensee must eliminate the interference or cease operations" and that the Commission require 30 day advance notification of any radio experiment so that incumbent licensees can "independently" review proposal. Reply Comments of BellSouth Corporation, CC Docket 98094, August 5, 1998 at p.6

conventional licensees who may have lingering doubts about how much experiments might disrupt their operations.

2. NTIA Coordination

Nortel Networks, in its comments to the Public Notice, stated that in order to promote the competitiveness of U.S. manufacturers in international markets the Commission needs to adopta more relaxed policy towards experimental licensing or developmental authorizations for product experimentation, verification and testing. Nortel indicates that these authorizations would enable development of equipment for overseas sales, where the regulations may not correspond with those in the U.S. It argues if manufacturers are unable to perform the necessary live-air experimentation required to develop or improve products for markets outside of the U.S., manufacturers may he limited in product development and thereby inhibited in their ability to compete in the international marketplace.[30] Further discussions with Nortel staff revealed difficulty in obtaining experimental licenses for two systems that were being developed in their U.S. laboratory for overseas sales and whose operating frequency was in a band used by the Federal Government in the U.S. Nortel indicated that in both cases it was unable to meet with the NTIA's managers who had concerns and try to develop a modification to their application to limit power, frequency range, operating hours, operating location, or other parameters in order to conduct the proposed test without interference to Federal Government systems.

Motorola indicated similar concerns stating that in some instances, experimental licenses are necessary to develop and test equipment in the US. that is destined for export sales. According to Motorola, this requires short-term use of spectrum allocated for Government services and therefore under the control of the NTIA. Motorola asserts that the NTIA, under the auspices of the Department of Commerce, should welcome such use of the spectrum on a coordinated basis, especially when the outcome is sales of product into foreign countries, which helps the balance of trade. Motorola further states that it has at times experienced delays of 12 months or more in obtaining NTIA approval and delays longer than a few months can be the difference between successfully deploying product into a foreign marketplace or being denied critical sales.[31]

Motorola has also suggested parallel review by FCC of potential interference of experiments to Federal Government systems, a procedure for allowing applicants to discuss with NTIA directly any concerns about applications and to negotiate possible modifications to eliminate interference threat to Federal systems.[32] Finally, Motorola suggested that the Commission set aside at least 50 MHz of spectrum between 2 and 4 GHz "for the development of advanced mobile communications systems."[33]

"Comments of Nortel Networks, **ET** Docket 02-135, at **p.** 2

[31] **"A** White **Paper an** Future Federal Communications Commission Spectrum Policy," Motorola, **ET** Docket 02-135, August 30,2002 at **p.** 26.

[32] Motorola, *op. cit.* at p. 26

[33] *Ibid.* **p. 25**

At the public workshop on August 1, 2002, concerns were also raised about the apparent lack of transparency of the NTIA coordination process from the point of view of private entities seeking to experiment with new technology.[34]

As indicated above, experimental applications that request use of spectrum that is used exclusively by the Federal Government or shared with the Federal Government are required to be coordinated with NTIA. In practice, NTIA refers such applications to the Interdepartmental Radio Advisory Committee (IRAC), which is composed of all federal agencies that are major spectrum users.[35] While many coordination requests are handled promptly by NTIA, it does appear some applications remain in the coordination process for a considerable period of time and in some instances are not resolved after periods in excess of one year.[36]

The UEWG recognizes that NTIA coordination is necessary to ensure that experimental operations do not adversely impact important Federal Government use of the spectrum. It does appear, however, that based on the public comments and the FCC's experimental licensing data that certain changes may be warranted.

While experimental licenses in bands with Federal Government assignments pose a possible interference risk to those systems, such experiments also have potential benefits for all radio users through facilitating the development of new technology and also have potential economic benefit such as increased export sales. The Task Forces suggests that in considering the coordination of such licenses that NTIA should consider the benefits of experimentation and the public interest balancing of them with possible interference risks to Federal Government systems.

Parties have also indicated an interest in being able to communicate directly with the Federal Government entities concerned about their pending experimental applications on a more regular basis. They note that there is no general requirement for Federal Government users to try to seek a compromise solution to a possible conflict resulting from a proposed experiment. These parties suggest such contacts would allow them to explore possible modifications that might lead to mutually acceptable outcomes such as restricting location, operating power, and operating hours?' The UEWG recognizes that classification issues related to certain Federal Government

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[34] See Transcript of August 1, 2002 Workshop on Unlicensed Spectrum and Experimental Licenses, Remarks of David Reed at p. 201 and DeWayne Hendricks at p. 207. Hendricks stated the following at the workshop:

> "It seems to me that without transparency, and whether the government owning so much of the spectrum, we're going to continue to have that problem, and it's going to hurt-- you know, it's going to basically mean that anybody who either competes with the government, or might have a better use for the spectrum than the government, or might even be developing technology that would ultimately benefit the government, has an extremely high burden to bear of many years of delay, if nothing else, while they try to work through a non-transparent system."

[35] NTIA coordination is actually carried out by the IRAC Frequency Assignment Subcommittee (FAS).

[36] OET's Experimental Branch has recently instituted a procedure in which new applications that not successfully coordinated in one year are dismissed without prejudice.

[37] Another tool for resolving conflicts in extreme case might be real time coordination of experimental operations with the Federal Government user of the spectrum and immediate cessation in case of interference or unexpected (continued....)

systems may make direct communication impractical in all cases. Nevertheless, in most instances it believes that communications between the parties is possible[38] and that new procedural and organizational mechanisms should he considered to improve communications between commercial parties desiring to implement experiments and Federal users of the spectrum.

3. Transparency of Spectrum Available far Experiments

FCC permits experimental license applicants to propose any frequency and location for their experiment. The FCC license database is publicly available and can be accessed over the Internet. However, frequency assignment information for Federal Government users can contain classified information and this information is not generally available to potential applicants. This necessity to classify certain Federal Government frequency assignments complicates the issue of using such spectrum for experiments. Further, even though the FCC information is available, the dynamic nature of frequency allocations in recent years with reallocations between services means potential experimenters who are not experts in U.S. spectrum use may not he able to identify readily non-Federal Government spectrum that may be available for experiments on a non-interfering basis.

The UEWG believes that it would be beneficial to be able to identify certain frequency bands, locations and times where and when experiments generally may be conducted. With regard to Federal Government spectrum, the UEWG believes that one potential approach to this problem deals with the several bands now in transition from Federal Government use to non-Federal Government use. Non-government long term commercial operations cannot be licensed and operated in such bands until the transitions are completed and government systems are re located. However, *all* such bands are not in use ***everywhere*** in the country ***at all times.*** There are likely opportunities for experiments in these bands on a non-interfering basis today if only one could determine the appropriate locations, frequencies, and times. The classification of NTIA assignments makes this difficult, if not nearly impossible, for private sector entities.

While it would be impractical, and probably a classification problem in itself, for NTIA to identify all location, frequency, and time combinations within the transfer bands that are practical for radio technology experiments, it would be possible with a modest amount of effort to identify a few areas of the country, preferably urban areas, where specific transfer bands are not presently in use and are not expected to be used prior to the final transfer to FCC control. NTIA could identify a small number of frequency and location pairs that it could announce and FCC could indicate that experimental license requests for those bands would not be delayed for lengthy NTIA coordination purposes, as they bad initial preapproval.

(...continued from previous page)
increases in the Federal Government user's need for spectrum due to local emergencies. This approach appears to have been used in some past cases.

[38] In some cases where direct communications between an applicant and the affected Federal Government user is not possible due to classified information, **NTIA** might wish to act **as** or appoint a third **party** to act as a **go** between.

Similarly, FCC could identify locations and blocks of spectrum in bands with pending reallocations, for example, in TV channels **52-69,** in which interference to ongoing operations is of negligible risk and for which experimental licenses could likely expect timely approval. While the basic information on TV channel use is publicly available, small high tech firms may not be familiar with the structure of the FCC license databases and the generally accepted propagation models that would be used to consider the interference risk of a specific experiment. "Pre-clearing" frequency and location pairs would reduce the risk and delays associated with applying for an experimental license and might stimulate radio technology experimentation in entrepreneurial firms. Alternatively, FCC could publicize what quantitative criteria it will use for approving experimental licenses in these bands.

C. Experimental License Recommendations

The UEWG makes the following recommendations with regard to the experimental authorization process:

- Interference and its definition are a key issue in the approval and operation of experimental licenses. All Task Force Recommendations for narrowing the ambiguities of today's definition will facilitate experimentation in the future and lead to a better understanding of the rights of both experimenters and other incumbent licenses.

- The UEWG recommends that NTIA consider a new interface for the non-federal Government spectrum users with IRAC members to help search for workable compromises for experimental applications and suggest that NTIA or DOC to appoint an advocate/ombudsman for the private sector.

Most coordination of experimental licenses with NTIA goes smoothly, but there are a few recurring cases that have problems – often involving testing of equipment intended for foreign markets. Yet in order to compete in world markets, US manufacturers must develop equipment that is designed for foreign environments. Recognizing that security classified information about Federal Government spectrum use must continue to be protected, there is an important need to improve the transparency of the NTIA coordination process and try harder to search for solutions to spectrum problems associated with experiments. The UEWG recommends that NTIA consider a new interface for the non-federal Government spectrum users with IRAC members to help search for workable compromises for experimental applications and suggest that NTIA or DOC to appoint an advocate/ombudsman for the private sector.

- Identify spectrum from government transfer bands and non-government spectrum with pending reallocations where experiments could be permitted under certain specified and publicized conditions.

With the ongoing transfer of bands from Federal Government use to FCC control, it is natural to expect that private entities may be interested in experimenting with new possible uses for such spectrum. Experimental licenses in such bands are possible today, but the lack of publicly available information on present government use of the bands creates an implicit entry barrier for such experiments. Extensive monitoring by potential applicants might reveal (location, frequency, time) combinations that would permit experimentation but the requirement

for such monitoring raises significant entry costs and there is always the possibility of some contingent use that monitoring would not reveal. lnfonnation from NTIA frequency assignment records would make it easier to identify such opportunities for experimentation. For example, they might show that in a specific band scheduled for transfer there are no Federal Government assignments in Northern California and no contingencies expected to use that spectrum in that area. However, such information on Federal Government assignments is not available to the public due to security classification and security concerns, it is available to FCC and NTlA, and the UEWG recommends that NTIA and FCC review Federal Government assignment data in the transfer bands, identify and announce the availability of combinations of location, frequency and time that would he available now for experimental licensing under existing rules. The SPTF believes that such announcements would lower barriers to experimentation and protect sensitive information.

Similarly, there is spectrum now under FCC control, *e.g.* TV channels **52-69** that will be reallocated in the near future and can he expected to be of interest to firms interested in developing new technology. While information about licenses in these bands is in publicly available databases, there is little easily available information about how to find this information and what criteria the FCC would use for considering an experimental license in such hands. The SPTF recommends that the Commission compile and make publicly available background infomation for potential experimenters in these bands concerning reallocation schedules, current licensees, and technical criteria for avoiding interference such as required D/U ratios with existing licensees and acceptable propagation models.

IV. ACKNOWLEDGEMENTS

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